Wearable and Implantable Chemical Sensors – Opportunities and Challenges

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Despite the wide range of applications and tremendous potential of implantable sensors targeting chemo/bio-markers, bringing actual practical devices fully to market continues to be inhibited by significant technological barriers associated with long-term reliability, which is a key requirement for implants. This is so, even with devices that appear to be well engineered, focused on apparently fairly solid markets, and based on well-established sensing principles. Wearable chem/bio-sensors offer an interesting alternative, intermediate between the long-term vision of implantable devices, and the single use-disposable devices that are the current dominant use model. For example, wearable patch-type devices employing micro-needles for minimally invasive sampling of interstitial fluid enables through-skin continuous monitoring of glucose for up to two weeks [**1**]. However, despite this apparently promising breakthrough, large-scale adoption remains frustratingly elusive, and some users experience infection, allergic responses and issues related to adhesion. To bypass these issues, other body fluids have been targeted that allow non-invasive sampling. For example, wearable platforms for monitoring sweat chemistry in real-time have recently been reported [**2**,**3**]. However, while there are important applications associated with sweat chemistry such as hydration status, sweat does not provide the rich diversity of diagnostic information accessible from blood. The move by Google into the biosensing space is another interesting development. In partnership with Novartis, Google is focusing on glucose monitoring through a contact lens with an integrated electrochemical sensor that can communicate wirelessly, function for 24 hours (lenses are changed daily), and is in contact with ocular fluid, which has a glucose composition related to that of blood [**4**]. Similarly, the period up to the launch of the Apple iWatch witnessed a frenzy of speculation about whether it would have an integrated glucose monitoring capability [**5**]. Clearly, however, wearable chem/bio-sensors are inherently more complex and less dependable than the well-established physical sensors, as reflected in the difficulties in bringing these devices to market [**6**]. In this paper, I will examine the issues that currently limit the applicability of chemo/bio-sensors in wearable and implantable scenarios, and present ways through which the effective autonomous lifetime of these more complex sensors might be extended from the current norm of (at most) several days, towards much longer periods (ideally years), for example, through the development of 'sensing systems' based on bioinspired microfluidics.

References

1 See for example http://diatribe.org/abbott-freestyle-libre-transforming-glucose-monitoring-through-utter-simplicity-fingersticks, last accessed 27th October 2015.

2 W. Gao, S. Emaminejad, H.Y.Y. Nyein, S. Challa, K. Chen, A. Peck, H.M. Fahad, H. Ota, H. Shiraki, D. Kiriya, D.-H. Lien, G.A. Brooks, R.W. Davis, A. Javey, Fully integrated wearable sensor arrays for multiplexed in situ perspiration analysis, Nature. 529 (2016) 509–514. doi:10.1038/nature16521.

3 T. Glennon, C. O'Quigley, M. McCaul, G. Matzeu, S. Beirne, G.G. Wallace, F. Stroiescu, N. O'Mahoney, P. White, and D. Diamond, 'SWEATCH': A wearable platform for harvesting and analysing sweat sodium content, Electroanalysis, 28 (2016) DOI: 10.1002/elan.201600106.

4 See http://www.independent.co.uk/life-style/gadgets-and-tech/google-licenses-smart-contact-lens-technology-to-help-diabetics-and-glasses-wearers-9607368.html, last accessed 27th October 2015.

5 See for example http://www.phonearena.com/news/Apple-iWatch-to-arrive-in-October-with-curved-OLED-screen-blood-glucose-sensor-and-more_id56939, last accessed 27th October 2015.

6 Concept and development of an autonomous wearable micro-fluidic platform for real time pH sweat analysis, V. F. Curto, S. Coyle, R. Byrne, N. Angelov, D. Diamond and F. Benito-Lopez, Sensors and Actuators B-Chemical, 175 (2012) 263-270.